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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant(s): Alan JOHNSON

Serial No.: 10/020,974

Filed: DECEMBER 19, 2001

Title: ANTENNA

LETTER CLAIMING RIGHT OF PRIORITY

Assistant Commissioner for Patents
Washington, D.C. 20231

MARCH 7, 2002

Sir:

Under the provisions of 35 USC 119 and 37 CFR 1.55, the applicant(s) hereby claim(s) the right of priority based on:

Great Britain Application No. 0030971.6
Filed: DECEMBER 19, 2000

A certified copy of said Great Britain Patent Application is attached.

Respectfully submitted,

ANTONELLI, TERRY, STOUT & KRAUS, LLP

Carl I. Brundidge
Registration No. 29,621

CIB/rp
Attachment

The Patent Office

CERTIFIED COPY OF PRIORITY DOCUMENT

INVESTOR IN PEOPLE



The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

e undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) e Deregulation and Contracting Out Act 1994, to sign and issue certificates on behalf of Comptroller-General, hereby certify that annexed hereto is a true copy of the documents ginally filed in connection with the patent application identified therein together with the nent of inventorship and of right to grant of a Patent (Form 7/77), which was quently filed.

rdance with the Patents (Companies Re-registration) Rules 1982, if a company named h ertificate and any accompanying documents has re-registered under the Companies Act 8 ith the same name as that with which it was registered immediately before re-is ion save for the substitution as, or inclusion as, the last part of the name of the words bl mited company" or their equivalents in Welsh, references to the name of the company his rtificate and any accompanying documents shall be treated as references to the name w h it is so re-registered.

I cco nce with the rules, the words "public limited company" may be replaced by p.l.c., p P.L or PLC.

R egis ion under the Companies Act does not constitute a new legal entity but merely s ects company to certain additional company law rules.

Signed

Dated 15 February 2002

**Patents Form 1/77**

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# Request for grant of a patent

*(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)*

The Patent Office
Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference

PAT 00035 GB

2. Patent application number
*(The Patent Office will fill in this part)*

19 DEC 2000 **0030971.6**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

NOKIA MOBILE PHONES LIMITED
KEILALAHDENTIE 4
02150 ESPOO
FINLAND

Patents ADP number *(if you know it)*

05911995004

If the applicant is a corporate body, give the country/state of its incorporation

FINLAND

4. Title of the invention

ANTENNA

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

NOKIA IPR DEPARTMENT
NOKIA HOUSE
SUMMIT AVENUE
FARNBOROUGH
HAMPSHIRE
GU14ONG UK

Patents ADP number *(if you know it)*

7577638001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

| Country | Priority application number *(if you know it)* | Date of filing *(day / month / year)* |
|---|---|---|

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

| Number of earlier application | Date of filing *(day / month / year)* |
|---|---|

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

*a) any applicant named in part 3 is not an inventor, or*
*b) there is an inventor who is not named as an applicant, or*
*c) any named applicant is a corporate body.*
*See note (d))*

YES

## Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

| | |
|---|---|
| Continuation sheets of this form | |
| Description | 8 |
| Claim(s) | 2 |
| Abstract | 1 |
| Drawing(s) | 5+5 |

10. If you are also filing any of the following, state how many against each item.

| | |
|---|---|
| Priority documents | |
| Translations of priority documents | |
| Statement of inventorship and right to grant of a patent *(Patents Form 7/77)* | |
| Request for preliminary examination and search *(Patents Form 9/77)* | 1 |
| Request for substantive examination *(Patents Form 10/77)* | |
| Any other documents *(please specify)* | |

11. I/We request the grant of a patent on the basis of this application.

Signature Kones Date 19/12/00

KENDRA JONES

12. Name and daytime telephone number of person to contact in the United Kingdom: Adam Franks 01252 865015

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*After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.*

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*b) Write your answers in capital letters using black ink or you may type them.*

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Patents Form 7/77
Patent Acts 1977
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**The Patent Office**

# Statement of inventorship and of right to grant of a patent

**7/77**

**The Patent Office**
Cardiff Road
Newport
Gwent NP10 8QQ

| | | |
|---|---|---|
| 1. | Your reference | PAT 00035 GB |
| 2. | Patent application number | 0030971.6 |
| 3. | Full name of the or of each applicant | NOKIA MOBILE PHONES LIMITED |
| 4. | Title of the invention | ANTENNA |
| 5. | State how the applicant(s) derived the right from the inventor(s) to be granted a patent | By virtue of Section 7(2)(c) |
| 6. | How many, if any, additional Patents Forms 7/77 are attached to this form? | |
| 7. | | I/We believe that the person(s) named over the page (and on any extra copies of this form) is/are the inventor(s) of the invention which the above patent application relates to.<br>Signature [signature] Date 14/1/02<br>Helen Haws |
| 8 | Name and daytime telephone number of person to contact in the United Kingdom | Helen Haws - 01252 865262 |

**Patents Form 7/77**

Enter the full names, addresses and postcodes of the inventors in the boxes and underline the surnames

ALAN JOHNSON
10 Barnes Road
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Fulham, London SW6 5LJ

8304495001

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Reminder
Have you signed the form?

PAT 00035 GB

# ANTENNA

This invention relates to an antenna, and in particular a dual mode antenna.

Mobile communications are becoming increasingly popular partly due to an increase in performance of communication devices and also to a decrease in their size.

One area, however, in which size reduction runs counter to performance is in antenna design where, generally, smaller antennas give reduced performance compared to larger antennas.

Consequently, to minimise space requirements in communication devices, for example a radiotelephone, the type of antenna typically used is a monopole antenna. The monopole antenna acts as a conductor placed counterpoised to a ground plane, typically a printed circuit board (PCB) in the radiotelephone. The conductor forms an image in the ground plane such that the resulting antenna pattern is a composite of the 'real' antenna (i.e. the monopole antenna) and the 'image' antenna (i.e. the image in the ground plane). Accordingly, a monopole antenna can be half the size of an equivalent dipole antenna providing that the groundplane makes up the other half of the dipole.

However, as communication devices reduce in size so typically does the ground plane associated with the communication device.

Consequently, if the electrical length of the ground plane becomes less than a quarter wave length of the 'real' antenna the antenna image is unable to match the current flow in the 'real' antenna. As a result, the efficiency of the antenna decreases such that either the bandwidth of the antenna is reduced, thereby reducing the performance of the communication device, or a larger

'real' antenna is required in order to compensate for the reduction in size of the ground plane, thereby increasing the size of the communication device.

One solution to this problem has been to use narrow bandwidth antennae that are tuned between different frequencies using a switched matching network. By moving the resonant frequency of an antenna between a range of frequencies can be used to simulate a wide bandwidth antenna. However, this solution can increase the complexity and cost of an antenna arrangement and can also reduce performance.

It is desirable to increase the bandwidth of an antenna without a corresponding increase in the size or complexity of a communication device.

In accordance with an aspect of the present invention there is provided an antenna comprising a first resonator element for coupling to an antenna feed; a second resonator element for coupling to ground; the first and second resonator elements arranged to allow field coupling between the first and second resonator elements such that at a first frequency the first and second resonator elements co-operate to allow operation of the first and second resonator elements in a first mode and at a second frequency the first and second resonator elements co-operate to allow operation of the first and second resonator elements in a second mode.

This provides an advantage of allowing a single antenna to have two modes of operation; in a first mode the antenna behaves as a first type of antenna, and in a second mode the antenna behaves as a second antenna type. According to the present invention in the first mode the antenna behaves as a coupled monopole antenna, and in the second mode the antenna behaves as a type of planar inverted F antenna (PIFA). By selecting the resonant frequencies of the two antenna modes to be slightly different this allows the two resonant bandwidths to be combined to allow the antenna to have a large bandwidth.

Preferably the first resonator element has a first electrical length and the second resonator element has a second electrical length.

This provides the advantage of easily selecting the resonant frequencies of the two antenna modes to be slightly different.

Preferably the first resonator element is arranged in a planar configuration.

Preferably the second resonator element is arranged in a planar configuration.

Suitably the first and second resonator elements are separated in a manner which allows coupling between the resonator elements. The separation may be in a parallel plane or may be transverse.

If desired, a dielectric substrate can be disposed between the first and second resonator elements.

Suitably an antenna according to the present invention may be mounted internally or externally to a suitable communications device.

For a better understanding of the present invention and to understand how the same may be brought into effect reference will now be made, by way of example only, to the accompanying drawings, in which:

Figure 1 shows a radiotelephone in accordance with a first embodiment of the present invention;

Figure 2 shows the impedance bandwidth of an antenna according to the first embodiment;

Figure 3 shows the efficiency of an antenna according to the first embodiment;

Figure 4a and 4b shows the current flow in an antenna according to the first embodiment;

Figure 5 shows a radiotelephone in accordance with a second embodiment of the present invention;

Figure 6 shows the impedance bandwidth of an antenna according to the second embodiment; and

Figure 7a and 7b shows the current flow in an antenna according to the second embodiment.

The radiotelephone of Figure 1 includes a housing within which is mounted a printed circuit board (PCB) on which are located the electronic components of the radiotelephone, including a transceiver for receiving and transmitting a signal. The housing includes a user interface (not shown) to allow a user to operate the radiotelephone. In addition the radiotelephone also includes an antenna that is mounted externally to the housing.

The antenna comprises a first resonator element and a second resonator element. The first resonator element is a thin flat conductive element arranged as a meandered monopole, as shown in figure 1, to form a planar element. The first resonator element is coupled to the transceiver via a feed.

The second resonator element is of similar design to the first resonator element (i.e. the element is a thin flat conductive element that is arranged as a meandered monopole, to form a planar element). The second element is coupled to the ground plane of the radiotelephone, typically the PCB of the radiotelephone. The second resonator element is mounted in the same plane but transverse to the longitudinal direction of the first resonator element, as shown in Figure 1.

The first resonator element and second resonator element are mounted relative to each other to allow magnetic and electric field coupling between the first and second elements, as is well known by those to skilled in the art.

The lengths of the first resonator element and the second resonator element are selected so that at one frequency the first resonator element and the second resonator element behave as two closely field coupled folded monopole antennas and at another frequency the first resonator element and second resonator element behave as a two dimensional version of a planar inverted F antenna (PIFA).

In the closely coupled monopole mode current flows in the same direction in both the first resonator element and the second resonator element, as illustrated in Figure 4b, where the second resonator element is excited by mutual coupling with the first resonator element.

In the PIFA-type mode current flows in one direction in the first resonator element and in the opposite direction in the second resonator element, where the second resonator element acts as a ground plane to the first resonator element.

As the effective electrical length of the antenna for the two modes are different the two modes have different resonant frequencies. By selecting the appropriate lengths of the first resonator element and the second resonator element the two resonant frequencies can be chosen to be close to one another, thereby creating a wide bandwidth antenna.

The lengths of the resonator elements are preferably chosen to be one quarter of the wavelength of the desired resonant frequency. However, other lengths could also be used for the resonator elements including three quarters, one and one quarter etc. It should be noted that it is the electrical length of the resonator elements which is of primary importance. It is common for antenna elements to have a meandering pattern, for example as shown in Figure 1, in order to reduce the overall physical length of the antenna element whilst retaining the same electrical length.

Figure 2 shows the impedance bandwidth of an antenna according to a first embodiment of the present invention that has a first given electrical length and a second resonator element with a second given electrical length.

According to the first embodiment, the first resonator element has an electrical length of approximately 9cm, and the second resonator element has an electrical length of approximately 7cm. This gives resonant frequencies of approximately 830MHz and 960MHz respectively for the first and second resonator elements.

The first resonator element and the second resonator element co-operate together in the PIFA-type mode to produce a resonant frequency of 830 MHz. The first resonator element and the second resonator element co-operate together in the folded monopole mode to produce a resonant frequency of 960 MHz. From Figure 2 it can be seen that the associated bandwidths combine to provide a total bandwidth of approximately 180 MHz.

Figure 3 shows the efficiency of an antenna according to the first embodiment.

The signals fed to or received by an antenna, including the antenna according to the present invention, are alternating. It is for this reason that it is not important which one of the two resonator elements is fed and which one is grounded.

Figure 4a and 4b shows the current flow in an antenna according to the first embodiment of the present invention. In Figure 4a, in which the resonator elements are acting as a PIFA antenna, it can be seen that, in a first current phase, current flow runs up the first resonator element and down the second resonator element. In a second current phase (not shown) current flows down the first resonator element and up the second resonator element.

Once the frequency of the fed element exceeds approximately 890MHz the coupled resonator elements start to act as monopole antenna. Figure 4b shows the current flow in each of the resonator elements. It can be seen that, in a first current phase, current flows up the first resonator element and also up the second resonator element. In a second current phase (not shown) current flows down both the first and second resonator elements.

Figure 5 shows a radiotelephone in accordance with a second embodiment of the present invention. In this embodiment the first and second resonator elements are positioned in parallel planes substantially overlapping.

The second embodiment works in substantially the same way as the first embodiment, as described above.

The precise electrical lengths of the resonator elements will need to be adjusted depending on the degree of coupling between the two resonator elements. This can be achieved by measuring the frequency response of the antenna with a given degree of coupling and making adjustments to the electrical length of either or both of the resonator elements to provide the desired frequency response. A dielectric may also be disposed between the resonator elements to alter the frequency response of the antenna. Adjustments may also have to made to the electrical length of the resonator elements according to the properties of the chosen dielectric.

Figure 6 shows the impedance bandwidth of an antenna according to the second embodiment.

Figure 7a and 7b shows the current flow in an antenna according to the second embodiment.

The second embodiment of the present invention enables a narrower antenna to be produced, although since the two resonator elements are overlying, the

height will be slightly greater than that of an antenna according to the first embodiment of the present invention.

## CLAIMS

1. An antenna comprising a first resonator element for coupling to an antenna feed; a second resonator element for coupling to ground; the first and second resonator elements arranged to allow field coupling between the first and second resonator elements such that at a first frequency the first and second resonator elements co-operate to allow operation of the first and second resonator elements in a first mode and at a second frequency the first and second resonator elements co-operate to allow operation of the first and second resonator elements in a second mode.

2. An antenna according to claim 1, wherein the first resonator element has a first electrical length and the second resonator element has a second electrical length.

3. An antenna according to claim 1 or 2, wherein the first mode is a coupled monopole mode.

4. An antenna according to any preceding claim, wherein the second mode is a planar inverted F type mode.

5. An antenna according to any preceding claim, wherein the first resonator element forms a monopole antenna.

6. An antenna according to any preceding claim, wherein the second resonator element forms a monopole antenna.

7. An antenna according to claim 5, wherein the first resonator element is arranged in a planar configuration.

8. An antenna according to claims 6, wherein the first and second resonator elements are arranged in a planar configuration.

9. An antenna according to claim 8, wherein the first and second resonator elements are transversely separated in the plane of the monopole antennas.

10. An antenna according to claim 8, wherein the first resonator element is separated from the second resonator element in a plane parallel to the second resonator element.

11. An antenna according to any preceding claim, wherein a dielectric substrate is disposed between the first and second resonator elements.

12. A communication device having an antenna according to any of the preceding claims.

13. A communication device according to claim 12, wherein the antenna is mounted internally to the communication device.

14. A communication device according to claim 12, wherein the antenna is mounted externally to the communication device.

15. An antenna substantially as hereinbefore described with reference to the accompanying drawings, and/or as shown therein.

16. A communication device substantially as hereinbefore described with reference to the accompanying drawings, and/or as shown therein.

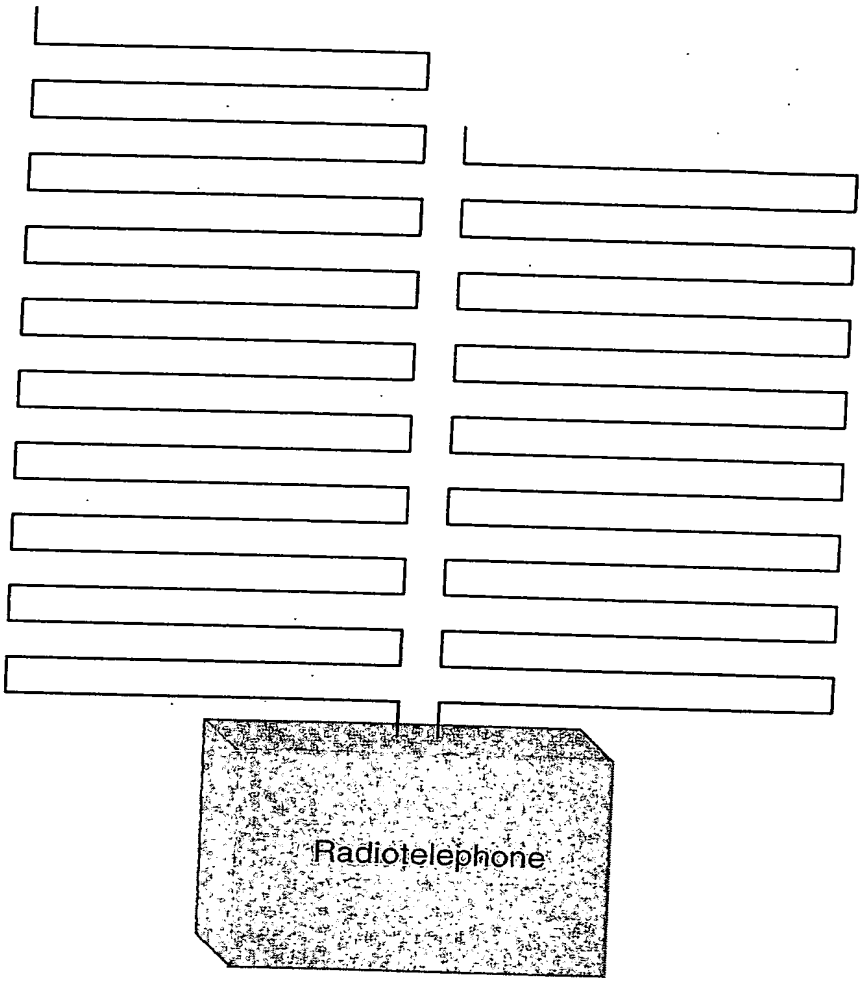



Figure 1

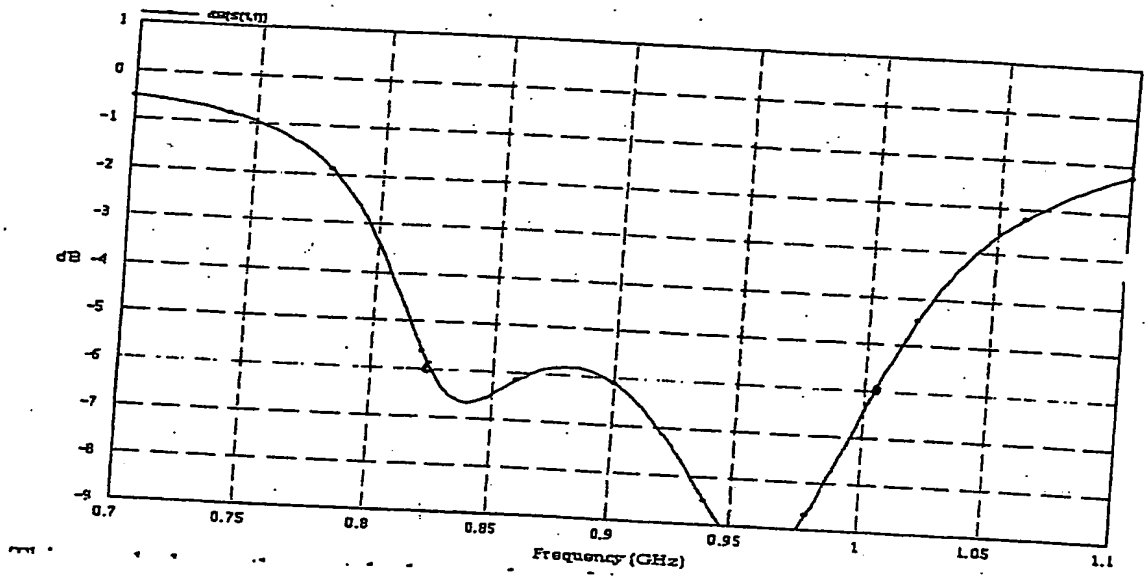



Fig 2

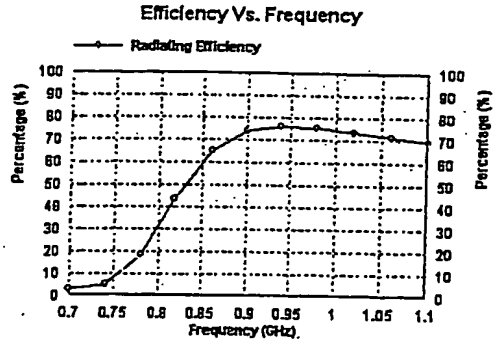



Fig 3

FIG 4a

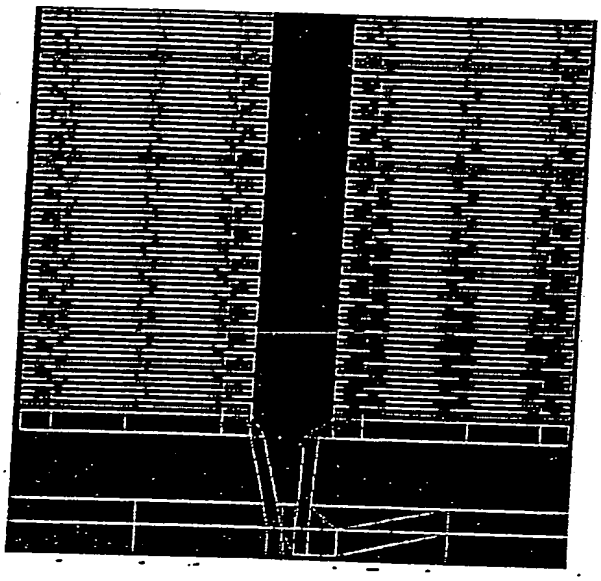
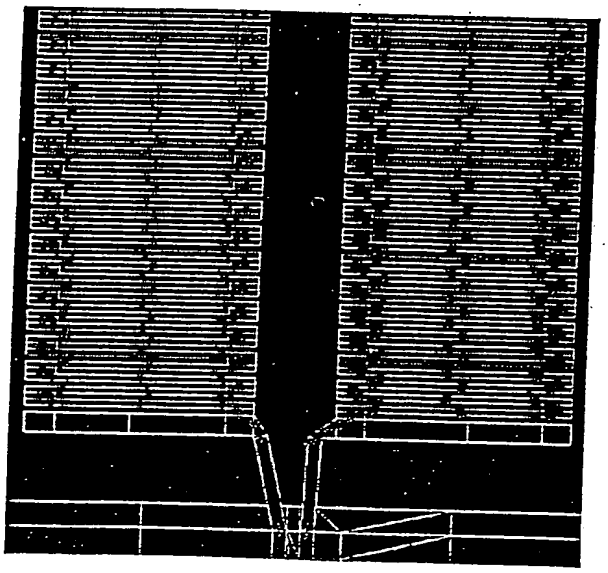


FIG 4b



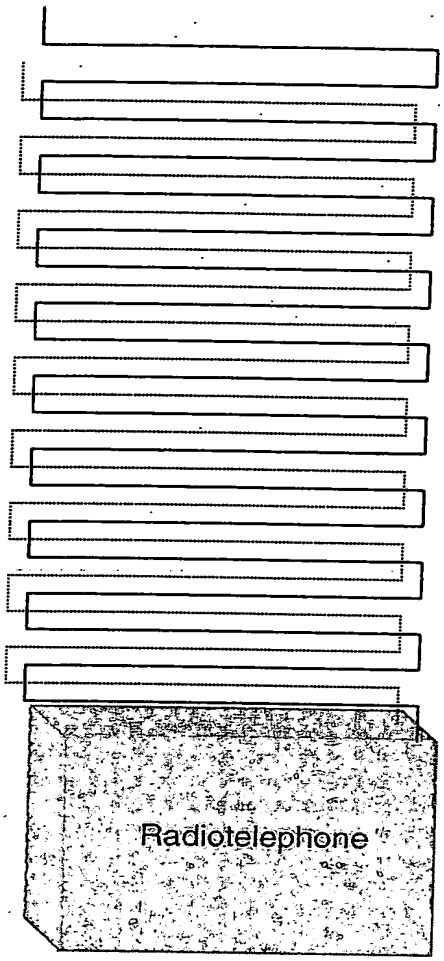



Figure 5

FIG 6

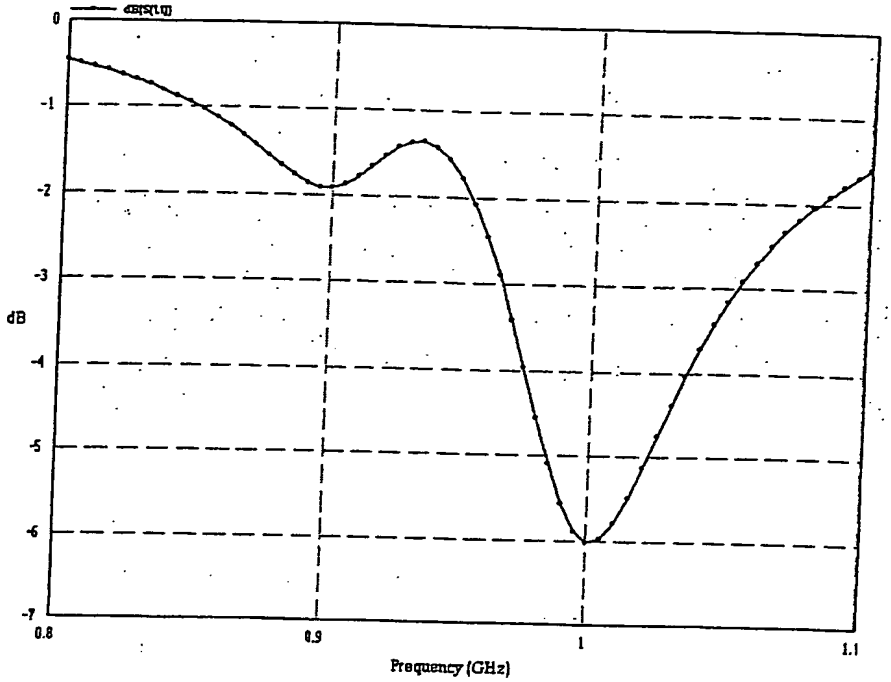
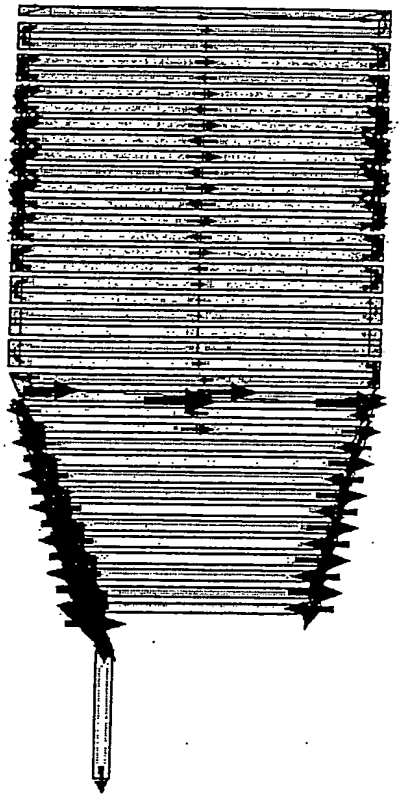



FIG 7a



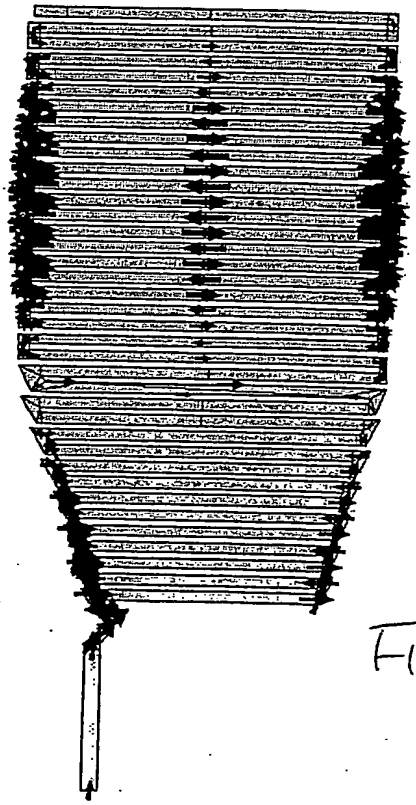


FIG 7B.